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## Fostering university students' metacognitive regulation through peer tutoring

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### Abstract

University students often possess insufficient metacognitive skills to self-regulate their learning adequately. This study investigates the impact of reciprocal peer tutoring (RPT) on students' adoption of metacognitive skills and on their approach to metacognitive regulation. A quasi experimental pretest-posttest design was adopted, involving an experimental (n=51) and two comparison groups; CG1 (n=24) and CG2 (n=22). Experimental students participated in the RPT-intervention. Students' regulation was assessed using think-aloud protocol analysis. Results indicate that RPT-students increasingly use metacognitive orientation, monitoring, and evaluation at posttest; evolutions which are not shown in the comparison groups. Significant effects on students' metacognitive planning could not be distinguished. Despite a significant evolution towards more deep-level comprehension monitoring for RPT-students, all participants' metacognitive regulation remains dominantly low-level.

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**Keywords:** Metacognitive regulation; peer tutoring; collaborative learning; higher education; think-aloud protocol analysis

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### 1. Introduction

Since metacognitive regulation is central to self-regulated learning (Butler, 2002; Efklides, 2008) and contributes to students' learning performance (Pintich & De Groot, 1990; van der Stel & Veenman, 2010), its promotion is assumed to be a worthwhile objective in current education (Meijer, Veenman, & van Hout-Wolters, 2006; Zimmerman & Schunk, 2011). Especially higher education – with its emphasis on self-management and independent learning – requires metacognitively skilful learners (Bruinsma, 2004; Heikkilä & Lonka, 2006). However, only few higher education programs succeed in effectively preparing students for metacognitive self-regulation (Maclellan & Soden, 2006), revealing a need to explore initiatives fostering metacognitive regulation. In this respect, new perspectives on learning and metacognition highlight the facilitative nature of collaborative learning and shared knowledge construction when promoting metacognitive regulation (Hadwin, Järvelä, & Miller, 2011). During collaborative learning, students explicitly feel the need to regulate the interactions and learning processes taking place, since they are prompted to engage in collaborative goal setting, to control their own and each

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other's comprehension, and to check collaboratively on learning outcomes (Hurme, Palonen, & Järvelä, 2006; Volet, Vauras, & Lehtinen, 2009). Despite growing consensus on the potential of collaborative learning, empirical evidence concerning its metacognitive effectiveness remains scarce (Iiskala, Vauras, Lehtinen, & Salonen, 2011). The present study aims to contribute in this respect by investigating the impact of reciprocal peer tutoring – as a specific type of collaborative learning – on university students' use of metacognitive regulation skills.

## 2. Theoretical framework

Metacognitive regulation refers to a set of self-regulatory skills and strategies used by students to control and to coordinate their learning and performance (Efklides, 2008; Meijer et al., 2006). Based on Brown (1987) and Veenman, Elshout, and Meijer (1997) we distinguish orienting, planning, monitoring, and evaluating as the major regulation skills. Metacognitive *orientation* takes place prior to problem solving and is aimed at preparing the latter (Veenman, Kok, & Blöte, 2005; Meijer et al., 2006). During orientation, students ideally engage in task-analysis by exploring task components and/or learning objectives (Butler, 2002). In some learners, task analysis results in awareness of their task perceptions (Veenman et al., 1997) or the activation of prior knowledge (Meijer et al., 2006). Closely related to orientation is metacognitive *planning*, referring to the selection and sequencing of problem solving strategies into a concrete action plan (Veenman et al., 1997). Planning strategies can be adopted at the onset or during academic problem solving, for example after completing a subtask. Metacognitive *monitoring* involves the online control of both students' comprehension and their progress, aimed at modifying problem solving when needed (Moos & Azevedo, 2009). When students monitor their comprehension, they check the correctness or comprehensiveness of their understanding (Meijer et al., 2006). Monitoring of progress, on the other hand, is focused on the adequacy and perceived quality of problem solving strategies or proposed task solutions (Butler, 2002; Moos & Azevedo, 2009). Finally, metacognitive *evaluation* refers to students' appraising actions upon completion of problem solving (Veenman et al., 2005). Students' evaluative judgements can be directed at both learning outcomes and process factors (Meijer et al., 2006).

Students' metacognitive regulation is characterised by the use of different regulation strategies, associated with students' approach to learning (Case & Gunstone, 2002). Deep learning, aimed at integrative knowledge construction, is often related to more metacognitive regulation and the use of more profound regulation strategies (Chin & Brown, 2000). Surface learning, on the other hand, generally gives less input to regulative control of learning (Case & Gunstone, 2002; Chin & Brown, 2000). Based on the underlying perspective on surface and deep approaches to learning, the present study makes a distinction between low-level and deep-level metacognitive regulation. Low-level regulation refers to basic regulation strategies which should minimally be employed by students to consider their behaviour as metacognitive, whereas deep-level regulation implies a more profound metacognitive involvement from students. For example, students can control their comprehension by reviewing information, since being able to repeat the outlines of learning content displays their level of understanding (Chin & Brown, 2000). Such knowledge-telling (self-)explaining is considered a low-level comprehension monitoring strategy. In contrast, deep-level comprehension monitoring requires elaboration on learning content, for example through thought-provoking questions or integrative explanations (Roscoe & Chi, 2008).

Socio-cognitive models of metacognition emphasise the need for a multi-dimensional approach when promoting metacognitive regulation, with modelling, prompting, and reflection as key elements (Hurme et al., 2006; Iiskala et al., 2011; Schraw et al., 2006). First, students' metacognitive awareness should be raised through direct observation of explicitly modelled metacognitive behaviour (Schunk & Zimmerman, 2007). Second, students should be prompted to internalise the modelled behaviour, which requires practising with metacognitive regulation strategies. Such practice encourages student to reflect upon the regulation strategies they adopt and consequently to optimise their metacognitive regulation (Schraw et al., 2006; Schunk & Zimmerman, 2007). Third, a powerful learning environment should be established, in which students are challenged to clarify, control, and judge their learning (Hurme et al., 2006; Puntambekar, 2006). As a result, collaborative learning environments are assumed to be promising metacognitive facilitators, for conceptual peer discussions, shared knowledge construction, and joint problem solving promote students' involvement in metacognitive regulation (Iiskala et al., 2011; Volet et al., 2009).

The present study aims to provide more insight in this respect by investigating the impact of reciprocal peer tutoring on university students' adoption of metacognitive regulation.

Peer tutoring is a specific type of collaborative learning in either small groups or learning pairs, which is characterised by peers adopting specific roles of tutor and tutee (Topping, 2005). The tutor is the more experienced student who supports the learning processes through questioning, explaining, and scaffolding. The students receiving this kind of academic guidance are called 'tutees' (Falchikov, 2001; Topping, 2005). Reciprocal peer tutoring is characterised by the structured exchange of the tutor role among peers in the tutoring group/pair and enables each student to experience the specific benefits of both roles (Topping, 2005). Empirical evidence reveals that peer tutoring enhances students' self-regulated learning capacities (Shamir & Tzuriel, 2004) and generates positive effects towards tutors' and tutees' metacognitive monitoring and regulation (King, Staffieri, & Adelgais, 1998). Especially students in the tutor role demonstrate more comprehension monitoring through reflective knowledge-building (Roscoe & Chi, 2008).

### 3. Research questions and hypotheses

The present study aims to investigate the impact of university students' participation in reciprocal peer tutoring (RPT) on their metacognitive regulation. The following research questions are put forward:

- (1) What is the effect of RPT on university students' actual use of metacognitive regulation skills?
- (2) What is the effect of RPT on university students' approach to metacognitive regulation?

Since literature in general and theory on social regulation in particular, provides evidence for the metacognitive learning opportunities within collaborative learning (e.g. Hadwin et al., 2011; Iiskala et al., 2011; King et al., 1998; Schraw et al., 2006; Volet et al., 2009), we hypothesise that RPT will have a positive impact on students' metacognitive skill use. When tutoring and exploring learning content with peers, students increasingly experience the need to metacognitively regulate their own, the groups' or each other's cognition. Since increased regulatory control often results in the use of more profound metacognitive strategies (Case & Gunstone, 2002; Chin & Brown, 2000), we additionally hypothesise that RPT will promote students' involvement in the deep-level approach to metacognitive regulation.

### 4. Method

#### 4.1 Participants and setting

A quasi-experimental pretest-posttest design was used, involving an experimental and two comparison groups. Experimental students (n=51) participated in an RPT-intervention during a complete semester. The study was conducted in a naturalistic setting at Ghent University. The experimental group consisted of first-year students Educational Sciences who already obtained a Professional Bachelor degree. Due to ethical reasons it was not possible to randomly assign these students to either an experimental or a control group. Therefore, we opted to involve two comparison groups. The first comparison group (CG1) consisted of 24 freshmen Educational Sciences, who are enrolled in the same university curriculum as the students in the experimental group. However, the CG1-students' background is somewhat different from the experimental students' background. The second comparison group (CG2) consisted of 22 first-year Social Welfare students who already obtained a Professional Bachelor degree. Although these students are enrolled in a somewhat different university curriculum, their background is comparable to the experimental group. No students in the comparison groups were involved in tutoring. The students in the experimental group were randomly assigned to small RPT-groups of six students each.

#### 4.2 Intervention

The RPT-program consisted of eight weekly face-to-face sessions of two hours. The tutor role was changed at each session. During each session, students worked on authentic group assignments, related to content-specific themes of the course 'Instructional Sciences'. Given their complexity and extensiveness, the tasks required group

members' collaboration and high levels of cognitive processing (Puntambekar, 2006). The RPT-intervention was based on empirical guidelines promoting effective tutoring (Topping, 2005). First, all experimental students participated in a compulsory preliminary tutor training (Falchikov, 2001; Parr & Townsend, 2002). The tutor training was aimed at informing students about the multidimensional nature of the tutor role and at offering them opportunities to practice a variety of generic tutoring skills (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001). The focus was, more specifically, on establishing a safe learning environment, managing peer interaction, and stimulating tutees' knowledge construction and cognitive processing through questioning, explaining, and scaffolding (Falchikov, 2001; King et al., 1998; Topping, 2005; Webb & Mastergeorge, 2003). Second, ongoing support was provided to all experimental students by means of both an interim supervision session and two-weekly feedback sessions (Falchikov, 2001). Both encouraged students to reflect upon the adequacy of their tutor/tutee role and the dynamics in the RPT-group, aimed at optimising future peer collaboration (Parr & Townsend, 2002). Third, a session-specific 'tutor guide' was developed for students in the tutor role and was provided to them one week in advance. The 'tutor guide' offered additional information about the theoretical content to focus upon when tutoring peers, for literature highlights the need for a difference in tutors' and tutees' domain-specific knowledge (Falchikov, 2001; Topping, 2005). Furthermore, the 'tutor guide' provided examples on how to approach the problem solving process stepwise and consequently, structured the peer interaction up to some level. Well-structured peer tutoring programs are assumed to be more successful (Falchikov, 2001; King et al., 1998; Webb & Mastergeorge, 2003).

#### *4.3 Think-aloud protocol analysis*

Both at the start and at the end of the semester all participants' ( $n=97$ ) use of metacognitive regulation skills was pre- and posttested, by means of think-aloud protocol analysis (Meijer et al., 2006; van Someren et al., 1994). All students individually performed an academic task, of which the entire solution process was videotaped and transcribed afterwards. The individual think-aloud task comprised of a theoretical text and a real-life case relevant to the course 'Instructional Sciences'. Students were instructed to solve three thought-provoking questions about the text and to verbalise their thoughts and problem solving actions during task execution, resulting in verbal protocols on their (meta)cognitive behaviour (van Someren et al., 1994). In case they stopped verbalising during task execution, they were prompted by the assessor to continue thinking aloud (van Someren et al., 1994). To code and analyse the verbal protocols, a literature based coding instrument was used, representing a hierarchical model of metacognitive regulation, with orienting, planning, monitoring, and evaluating as main coding categories (De Backer, Van Keer, & Valcke, 2012). Additionally, a dimension on the approach was included to this coding instrument, explicitly indicating the low-level versus deep-level nature of diverse regulation strategies. The verbal protocols were transcribed verbatim and coded by two independent and trained coders. They double-coded 25% of all protocols to determine interrater reliability. Cohen's kappa ( $\kappa = .78$ ) indicates high overall agreement beyond chance.

#### *4.4 Data analysis*

After coding the verbal protocols, the occurrence of the different metacognitive regulation skills was calculated for each protocol (per participant). These frequencies were used for analysis purposes. To study the impact of RPT on students' actual use of metacognitive regulation skills (RQ1) and on their approach to metacognitive regulation (RQ2), a two-way mixed ANOVA was performed for each metacognitive skill, using condition (EG/CG1/CG2) as a between-subjects factor and measurement occasion (pretest/posttest) as a within-subjects factor. Post-hoc comparisons (Bonferroni test) were carried out to compare the main effects. The significance level was set up to 5% for all analyses.

## **5. Results**

At pretest, no significant differences are found between the three research conditions in their use of metacognitive orientation ( $F(2,94)=1.05$ ;  $p=.364$ ), planning ( $F(2,94)=2.94$ ;  $p=.353$ ), monitoring ( $F(2,94)=1.74$ ;  $p=.182$ ), or evaluation ( $F(2,94)=0.73$ ;  $p=.484$ ). At posttest, however, results of the mixed ANOVA reveal significant

interaction effects between measurement occasion and condition for metacognitive orientation ( $F(2,94)=19.98$ ;  $p<.001$ ; *partial*  $\eta^2=.29$ ), monitoring ( $F(2,94)=94.38$ ;  $p<.001$ ; *partial*  $\eta^2=.66$ ), and evaluation ( $F(2,94)=62.19$ ;  $p<.001$ ; *partial*  $\eta^2=.57$ ). Pairwise comparisons demonstrate that experimental students make significantly more use of these regulation skills at posttest compared to students from CG1 and CG2 (see Table 1). Both control groups do not differ significantly from each other, implying RPT-students evolve significantly more towards the adoption of orientation, monitoring, and evaluation skills. The metacognitive planning behaviour of students does, however, not differ significantly from pretest to posttest ( $F(1,94)=1.94$ ;  $p=.167$ ). No interaction effect between measurement occasion and condition is found either ( $F(2,94)=0.71$ ;  $p=.496$ ).

Table 1 Pairwise comparisons for metacognitive regulation as dependent variable

Metacognitive regulation skill	Condition (I)	Condition (J)	Mean difference (I-J)	SE	p <sup>a</sup>
Orientation	EG	CG1	1.42*	0.28	<.001
		CG2	1.04*	0.29	.002
	CG1	EG	-1.42*	0.28	<.001
		CG1	-0.37	0.34	.815
	CG2	EG	-1.04*	0.29	.002
		CG1	0.37	0.34	.815
Monitoring	EG	CG1	10.89*	0.87	<.001
		CG2	10.41*	0.90	<.001
	CG1	EG	-10.89*	0.87	<.001
		CG1	-0.47	1.04	1.000
	CG2	EG	-10.41*	0.90	<.001
		CG1	0.47	1.04	1.000
Evaluation	EG	CG1	2.00*	0.24	<.001
		CG2	1.93*	0.25	<.001
	CG1	EG	-2.00*	0.24	<.001
		CG1	-0.07	0.28	1.000
	CG2	EG	-1.93*	0.25	<.001
		CG1	0.07	0.28	1.000

<sup>a</sup> Adjustment for multiple comparisons: Bonferroni

\* $p<.05$

Results furthermore reveal that students in all research conditions are dominantly involved in low-level metacognitive regulation, both at pretest and at posttest. However, our findings also show a clear and significant positive pretest to posttest effect of condition on the adoption of metacognitive monitoring. More specifically, pairwise comparisons show that RPT-students outperform students from both CG1 (*mean difference*=3.61;  $p<.001$ ) and CG2 (*mean difference*=3.44;  $p<.001$ ) in the adoption of deep-level comprehension monitoring strategies at posttest ( $F(2,94)=48.66$ ;  $p<.001$ ; *partial*  $\eta^2=.51$ ). They tend to provide more personal interpretations and integrate information significantly more when inquiring about their understanding. The control conditions do, however, not differ significantly from each other (*mean difference*=0.18;  $p=1.00$ ).

## 6. Discussion and conclusion

With regard to the first research question, our results reveal a significantly increased use of metacognitive orientation, monitoring, and evaluation skills by RPT-students at posttest. This evolution could not be distinguished



for students in both comparison groups. A significant impact of RPT on students' planning behaviour was, however, not found. This might be due to the design of the think-aloud task, for the task partially determines the outcomes of protocol analysis (van Someren et al., 1994). Since students were expected to solve three thought-provoking questions, the opportunities to plan task execution might have been rather scarce.

Based on our results, RPT appears to have a major impact on students' use of metacognitive monitoring, more especially on their involvement in comprehension monitoring. At posttest, students with tutoring experience tend to check their comprehension significantly more frequently, by paraphrasing learning contents or elaborating on them. Based on the tutoring literature (e.g. Chi et al., 2001; Falchikov, 2001; King et al., 1998; Topping, 2005), a possible explanation can be found in the key elements of the tutoring setting, which can directly elicit monitoring behaviour. When tutoring each other, students get confronted with peers' alternative interpretations and are consequently challenged to negotiate meaning and revise their thinking (Chi et al., 2001; King et al., 1998). Additionally, tutors' thought-provoking questions and explanations are assumed to have a positive influence on students' awareness of the necessity to control and monitor one's understanding (Hurme et al., 2006; Roscoe & Chi, 2008; Webb & Mastergeorge, 2003). It seems plausible to assume that a semester-long experience in such a cognitively challenging tutoring context prompted students to internalize this comprehension monitoring behaviour.

With regard to the second research question, our findings reveal that both students from the experimental group and students from the comparison groups mainly adopt low-level regulation strategies, at pretest as well as at posttest. Nevertheless, RPT-students appear to evolve significantly towards more deep-level comprehension monitoring at posttest; an evolution which could not be discerned for students in the comparison conditions. RPT-students' increased engagement in deep-level comprehension monitoring might be explained by their enhanced use of and practice with metacognitive monitoring in general, for more regulatory control often results in the adoption of more profound metacognitive strategies (Chin & Brown, 2000).

Although the present study reports on a positive impact of RPT on university students' metacognitive regulation, caution is needed when interpreting the significant changes in students' metacognitive skilfulness. Since the present study was conducted in a naturalistic university setting, it was - due to ethical reasons - not possible to randomly assign students from the same group to either the experimental or control condition. Although two comparison groups were involved, these were somehow different because of differences in participants' background (e.g. age and prior studies in higher education) or their university curriculum. In other words, further research is needed to verify and explore the results of this study in depth. Since the metacognitive effectiveness of RPT might be promoted by specific interaction patterns within tutoring groups (Barron, 2003; Chi et al., 2001), process-oriented analyses of peers' contributions and (inter)actions could be interesting for further research as well. Video-analysis of RPT-interactions could also compensate for the methodological constraint of the present study and unravel explanations for the suggested metacognitive effectiveness of RPT.

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